THE PROSPECTS FOR CANADIAN URANIUM

by

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FOREWORD

This two-part working paper represents independent research supported by the Centre for Resource Studies and aimed at improving knowledge of the Canadian mineral industry and the political and economic environment in which it operates. In these studies, the author looks at changing market conditions for Canadian uranium, and at some of the factors affecting the international competitive position of Canadian uranium producers.

The Centre's working papers are offered for information and discussion, in an attempt to encourage feedback and additional research in mineral policy. Views expressed are those of the author, and do not necessarily represent the views of the Centre or its sponsors.

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Stephen Salaff
Toronto, July 1983

SUMMARY

The 1980s have seen a decline in markets for uranium concentrate, largely as a result of falling estimates for reactor fuel requirements and rising inventories. Spot market prices fell from the high of 1978 (over US $112 per kg U) to $44 in September 1982, but have since risen back to $60. World production also fell in 1982 and is not expected to increase significantly before 1990. Some opportunities do exist for Canadian producers with new low-cost deposits to replace high-cost producers in Canada and other countries, particularly the United States. There will however be strong competition between Canadian producers, including joint venture partners in the same projects, as well as from Australia. Australia's reserves are somewhat larger than Canada's, although the reported ore grades tend to be lower than those of Saskatchewan.

The most promising new deposits in Canada are located in northern Saskatchewan. They are relatively high grade, and some are suitable for open pit mining. Three new projects (Cluff Lake 2, Key Lake, and Collins Bay B) are scheduled to come into production over the next two and one-half years, and another three (McClean Lake, Dawn Lake, and Waterbury Lake) are considered to have good potential.

In view of the strategic importance of nuclear fuels, governments have played an important role in all phases of the uranium fuel cycle. For example, the international fuel supply industry has been shaped largely by the U.S. government, through its former monopoly of uranium enrichment services. All producer nations, including Canada, regulate the terms and conditions of uranium production and sales, and can influence the rate of production and even the scope of new projects.

Planning and analysis in the Canadian uranium industry would be facilitated by a clearer understanding of the federal government's system for uranium export contract approval. This in turn would promote more orderly and rational long-term solutions to problems of world energy supply and uranium resource development.

RESUME

On assiste depuis les années 1980 à un déclin des marchés du concentré d'uranium surtout parce que les prévisions des demandes de carburant à réacteur sont tombées et que les stocks ont augmenté. Les cours du marché au comptant ont plongé de plus de $112 américains le kg U (le cours le plus élevé en 1978) à $44 en septembre 1982, mais sont remontés depuis à $60. La production mondiale est également tombée en 1982 et on ne s'attent pas à ce qu'elle augmente de beaucoup avant 1990. Il existe quelques marchés pour les producteurs canadiens exploitant de nouveaux gisements à prix de revient bas qui prendront la place des producteurs dont les gisements sont à un prix de revient élevé au Canada et dans d'autres pays, notamment aux Etats-Unis. Il y aura cependant une forte concurrence entre les producteurs canadiens, y compris entre les associés d'entreprises participant aux mêmes projets. L'Australie sera une concurrente non négligeable, ses réserves étant plus importantes que celles de la Saskatchewan, bien que les teneurs de mineral constatées tendent à être inférieures.

Au Canada les nouveaux gisements les plus prometteurs se trouvent dans le nord de la Saskatchewan. La teneur en est relativement élevée, et quelques-uns se prêtent à l'exploitation à ciel ouvert. Trois nouveaux projets (Cluff Lake 2, Key Lake et Collins Bay B) doivent entrer en production au cours des deux ans et demi qui suivent et on pense de trois autres (McClean Lake, Dawn lake et Waterbury Lake) qu'ils ont au excellent potential.

Vu l'importance stratégique des combustibles nucléaires, les gouvernements ont joué un rôle prépondérant dans toutes les phases du cycle du combustible d'uranium. Par exemple, l'industrie internationale d'approvisionnement en combustible a été formée surtout par le gouvernement des Etats-Unis, au moyen de son ancien monopole des services de l'enrichissement de l'uranium. Tous les pays producteurs, y compris le Canada, réglementent les modalités de paiement et les conditions de la production et de la vente de l'uranium, et peuvent influencer le taux de production et même l'envergure de nouveaux projets.

Si le système dont se sert le gouvernement fédéral pour approuver les contrats d'exportation de l'uranium était mieux compris, la planification et l'analyse de l'industrie de l'uranium en seraient bien facilitées. Cela permettrait des approaches plus méthodiques et plus rationnelles pour trouver des solutions à long terme aux problèmes de l'approvisionnement mondial en énergie et du développement des ressources d'uranium.

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PART I CANADIAN URANIUM IN AN UNCERTAIN WORLD MARKET

Introduction

Narrowing sales opportunities on the international market since the turn of the decade have profoundly intensified the rivalries between suppliers of uranium yellowcake, the concentrate from the uranium milling process. The vigorous competition between suppliers for the limited available demand even extends to partners within joint production ventures.

Forecasts of nuclear generating capacity have been steadily reduced, resulting in lower estimates of reactor fuel requirements. 'The confidence of electrical utility planners in nuclear power has been eroded in some OECD (Organization for Economic Cooperation and Development) countries, as is evidenced by increasing cancellations of nuclear power plants and the increasing development of a wait-and-see attitude'.[1]

Unlike oil, gas and coal, uranium can be readily stored, and utilities have traditionally created substantial inventories (one or two times annual reactor demand in the United States, and somewhat higher elsewhere) by ordering more uranium than they burned in their reactors. But now, with delays, deferrals and cancellations of nuclear generating stations, inventories in the World Outside Centrally-Planned Economies Area (WOCA) could increase from 154,000 tonnes U in 1982 (about 4 times annual demand) to over 242,000 tonnes U by 1990 (about 4.4 times annual demand).[2] U.S. inventories peak earlier, at about 57,000 tonnes U (3.1 times annual demand) in 1983.[3] (The excess stockpiles are not evenly distributed among consumers, and supply security is more evident for some utilities than for others.)

Uranium production cutbacks reflect the perceptions of producers and users (utilities and reactor vendors) that a substantial price recovery may not be immediate, and that demand will remain weak in the short term. In 1980-82, many utilities in the USA and in OECD Europe who sought to liquidate their uranium surplus as soon as possible ironically became suppliers not only to other users but also to producers. Ninety percent of the uranium for near-term sale in July 1982 was offered by users, many of whom quoted distress prices below mine-mill production costs, while 70 percent of the active buyers were producers.[4] Production costs previously represented a floor under prices, but recent spot markets have come to resemble a roof.[5]

The spot market price, which is a widely-quoted but volatile barometer of the uranium trade,[6] decreased from over US$112 per kg U (US$43 per lb U_3O_8) in 1978

to about US$44 per kg U (US$17 per lb U_3O_8) in September 1982. But since October 1982 producers have become more active sellers, utilities have re-emerged as buyers, and spot prices have risen for eight consecutive months in the direction of long-term contract prices, which now average around US$91 per kg U (US$35 per lb U_3O_8).

WOCA uranium production declined in 1982 for the first time since 1974, and a further drop will be registered in 1983, after which Nuexco and Nukem forecast flat or slightly increasing output levels through 1990. The geographic distribution of the 41,300 tonnes U produced by WOCA in 1982 (table 1) shows that the cutback in U.S. output is the chief component of total production stagnation, which is partially offset by new supplies from Ranger in Australia and (beginning in late 1983) from Key Lake in Saskatchewan.

TABLE 1 WOCA URANIUM PRODUCTION IN 1982

Country	Tonnes U	Share of WOCA production (percent)	Production change from 1981 to 1982 (percent)	Production change forecast from 1982 to 1983 (percent)
Australia	4,470	10.8	+ 56.1	- 1.6
Canada	8,080	19.6	+ 3.5	+ 13.9
Europe	3,140	7.6	- 13.7	+ 5.1
Gabon	970	2.3	- 4.9	- 7.2
Namibia	3,780	9.2	- 4.8	- 7.4
Niger	4,260	10.3	- 2.3	- 3.8
South Africa	5,750	13.9	- 6.3	- 4.3
United States	10,330	25.0	- 30.2	- 31.3
Others	520	1.3	+ 106.8	- 3.8
Total	41,300	100.0	- 6.1	- 6.8

Source: Nukem Market Report, June 1983, p. 3.

Note: Nukem's figure for 1982 Canadian production exceeds the true value by 30 tonnes U but is retained for consistency of arithmetic calculations.

New Uranium Producers in Canada and Australia

'The Canadians with their high-grade Saskatchewan deposits are currently the principal and most aggressive long-term sellers in the world market', according to George White of Nuexco.[7] Canadian-based firms secured over one-half of the 15 to 20 intermediate and long-term yellowcake contracts signed or under negoti-

ation in the months from late 1981 to August 1982.[8] Combined with increasing production by Denison Mines Limited and Rio Algom Limited in the Elliot Lake area, the achievement in Saskatchewan of conservative production targets by the Rabbit Lake/Collins Bay, Cluff Lake and Key Lake mills could lift Canadian output from 7,722 tonnes U in 1981 and 8,050 tonnes U in 1982 to more than 10,000 tonnes U in 1984.[9] Moreover, a conservative projection of production capability based on low-cost resources associated with operating and committed production centres showed Canadian capability rising from 9,500 tonnes U in 1982 to 14,900 tonnes U by 1985.[10]

Canada will supplant the USA in 1983 as the largest WOCA uranium producer, followed before 1990 into second and third place by South African and Australian competitors. From 80 to 85 percent of Canada's output is destined for export, while South Africa and Australia ship still larger percentages of their yellowcake overseas. South Africa is now building its first nuclear power plant, which will draw on local raw materials, but the bulk of its uranium output has been and will continue to be exported or stockpiled. Australia has no firm plans to utilize fission power and its uranium has until the present been mined entirely for shipment abroad. In contrast, only about 11 percent of the uranium produced commercially in the USA during 1966-81 was exported.[11] The historic and forecast uranium output figures given in table 2 show the permutations anticipated in the ranks of the major producers.

TABLE 2 HISTORIC AND FORECAST URANIUM PRODUCTION BY THE MAJOR WOCA PRODUCING COUNTRIES

	1975		1980		1985		1991	
	(tonnes U)	%	(tonnes U)	%	(tonnes U)	%	(tonnes U)	%
United States	8,900	46	16,800	38	7,900	18	6,000	12
Canada	3,600	19	7,200	16	11,500	26	12,300	24
South Africa	2,500	13	6,100	14	7,000	16	7,000	14
Australia	-		1,600	4	4,200	9	10,600	21
Europe	2,000	13	3,000	7	3,000	7	3,100	6
Namibia	-		4,000	9	4,000	9	4,000	8
Niger and Gabon	2,000	10	5,100	12	uncertain		uncertain	
Total WOCA	19,300		44,000		45,000		51,500	

Sources: Uranium: Resources, Production and Demand (Paris: OECD Nuclear Energy Agency and International Atomic Energy Agency, December 1976) p. 24; Nukem Market Report, June 1982, p. 4, and October 1982, p. 5.

Bouyant markets in 1976-78 stimulated a dozen companies in Canada and Australia to plan new production centres. The four new uranium production ventures in northern Saskatchewan and Australia's six largest projects are listed in table 3. Some of these reached the mine development and mill construction stage before concluding long-term supply contracts.

The ore grades in situ of the deposits in the Athabasca Sandstone Basin of northern Saskatchewan average above 1 percent uranium, and although ore grades in the Alligator Rivers District of Australia's Northern Territory are lower, averaging about 0.33 percent uranium, they may exceed three times the average grade of all WOCA reserves.[12] On the other hand, the average grade of ore processed in the USA fell steadily from 0.20 percent U in 1966 to 0.10 percent U in 1979, and has then remained nearly constant.[13] Over 95 percent of South Africa's uranium is recovered as a byproduct in the deep underground mining of gold, and uranium oregrades thus depend on the mining-economic parameters of gold extraction. These grades are very low and, in tandem with the steady decrease in the grade of gold ore, declined monotonically from 0.039 percent U in 1964 to 0.017 percent U in 1980.[14] Ore grade averages disguise variations between mines and for a single mine over time; they are the result of many opposing forces coming into play, including the depletion of older mines and the opening of new facilities. But in general, the cyclical fluctuations in the USA, South Africa, and the province of Ontario have occurred around decreasing percentages.

The geologic potential of northern Saskatchewan and the Northern Territory is formidable, and the economic significance of the new generation of near-surface Canadian and Australian deposits exceeds even that indicated by the combined Canadian and Australian share of 30 percent of 1982 WOCA uranium production, and their 45 percent share forecast for 1991. The discovery rate in Saskatchewan has been almost one major deposit per year since 1968,[15] and prime exploration targets await evaluation near the sandstone edge of the Athabasca Basin.[16] Major new discoveries of unconformity deposits are considered quite likely in northern Saskatchewan and in Australia's Northern Territory.[17] Such deposits, which are found in Saskatchewan at or near the unconformity between the Athabasca sandstone and the underlying basement rocks, include Rabbit Lake and Key Lake. They are geologically distinguished from the lower grade vein-type deposits of the Beaverlodge District. The Ranger and Jabiluka deposits in the Northern Territory are also of unconformity-type.

Anticipated 1990 full costs of production capacity in 1981 dollars average US$65 per kg U in Saskatchewan and US$83 in Australia. These costs are much lower than those of US$120 and US$117 predicted for the United States and for the balance of WOCA respectively in 1990.[18] The entry into the market of low-cost

TABLE 3: NEW GENERATION CANADIAN AND AUSTRALIAN URANIUM PRODUCERS

Project	Actual or Future Target Date of First Production	Company-Announced Reserves (tonnes U)	Ore Grade (percent U)	Actual or Future Target Production capacity (tonnes U/YR)	Ownership
CANADA					
Cluff Lake 1	1980	4,000	7.0	1,500	Amok 80% + SMDC 20%
Cluff Lake 2	1984	12,710	0.4-0.5	1,000	Amok 80% + SMDC 20%
Key Lake	1983	73,610	2.0	4,600	SMDC 50% + Uranerz EML 33.3% + Eldor Resources 16.7%
Collins Bay B	1985	12,040	0.38	2,120	Eldor Mines 100%
AUSTRALIA					
Northern Territory:					
Nabarlek	1980	10,180	1.6	850	Queensland Mines = Pioneer Concrete 50% + Ampol 50%
Ranger	1981	106,000	0.15-0.28	2,500	ERA=Peko Wallsend 30.85% + EZ 30.85% + Australian public 13.3% + overseas participants 25%
Koongarra	1986	11,500	0.3	1,150	Denison 100%
Jabiluka	1988	175,640	0.33	3,800	Pancontinental 65% + Getty Oil 35%
Western Australia:					
Yeelirrie	1989	39,860	0.12	2,120	Western Mining 75% + Urangesellschaft 10%, other partners sought
South Australia:					
Olympic Dam	after 1990	1,018,000	0.05	2,540	Western Mining 51% + BP Australia 49%

Source: Company reports.
Abbreviations : SMDC = Saskatchewan Mining Development Corporation
Uranerz EM = Uranerz Exploration and Mining Limited
ERA = Energy Resources Australia
EZ = Electrolytic Zinc Company of Australasia Limited

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uranium from Saskatchewan and the Northern Territory was a blow to the uranium producers and price structure in the United States.

Production commenced in 1980 at Nabarlek and in 1981 at Ranger in the Northern Territory of Australia. The average grades of the vast Ranger (open pit) and Jabiluka (underground) deposits are 0.21 percent U and 0.33 percent U respectively, and they are expected to enjoy impressive economies of scale. The signing of a 42-year mineral lease with the Northern Territory government in August 1982 signified approval for development of the Jabiluka project, where the partners hope to negotiate sales contracts to support an initial annual production rate of 2,550 tonnes U in 1988, rising to 3,800 tonnes U shortly afterward. However, the new Labour government returned in March 1983 has withdrawn Ministerial Determinations conferring the ability to market uranium. An interdepartmental committee presently examining the uranium question is expected to report its findings to Cabinet during July 1983. Cabinet will then decide what action to take on new development projects.

While doubts are being expressed about Canberra's attitude to the early development of Jabiluka, the much smaller Koongarra project of Denison Mines and other proposed new uranium ventures, and about the expansion of the Ranger project, the Labour party has declared that the multi-mineral Olympic Dam (Roxby Downs) project will be encouraged as a major economic factor for South Australia. Ore reserves at Olympic Dam, a new type of strata-bound, sediment-hosted deposit, jointly owned by Western Mining Corporation Limited (51 percent shareholder) and BP Australia Limited (49 percent), are estimated to contain 2 billion tonnes with an average of 1.6 percent copper, 0.05 percent uranium, and 0.6 grams of gold per tonne. Possible annual production capacity is 150,000 tonnes copper, 2,540 tonnes uranium, 3.4 tonnes gold and 23 tonnes silver. (The reserve estimate of over one million tonnes U at Olympic Dam may be illustratively compared with the massive Elliot Lake orebodies in northern Ontario, which were estimated in the mid-1950s to contain 300,000 tonnes of commerically available uranium.) The completion of a feasibility study is expected by December 1984, followed by a decision not later than 1987 whether to proceed with mining at Olympic Dam. The estimated expenditure in 1981 dollars to establish the Olympic Dam project is US$1.2 billion.

The Rabbit Lake deposit of Gulf Minerals Canada Limited and Uranerz Canada Limited was the first of the northern Saskatchewan unconformity-related orebodies to be developed. The mine is now owned by Eldor Mines Limited, a subsidiary of Eldorado Nuclear Limited, a federal Crown corporation. The Rabbit Lake open pit mine-mill complex came on stream in 1975, and achieved annual production levels of between 1,800 and 2,000 tonnes U from 1977 to 1980.

Mining of the shallow open-pit Cluff Lake 'D' deposit in northern Saskatchewan, one of the richest ever discovered (average grade 7 percent uranium), was begun in 1980 at an annual rate of 1,500 tonnes U by Cluff Mining, a partnership of Amok Limited (80 percent) and the Saskatchewan Mining Development Corporation (20 percent), a Saskatchewan Crown corporation. Phase 2 at Cluff Lake will develop and mine new lower-grade orebodies (around 0.5 percent U) near the mill, which is being expanded for the purpose. Cluff Mining's schedule calls for construction of Phase 2 process facilities beginning in summer 1983, and for production from late 1984 until 1995 at an annual rate of between 850 and 1,250 tonnes U. The partnership exports most of its output to utilities in France and West Germany.

Key Lake Mining Corporation, a joint venture of SMDC (one-half), Uranerz Exploration and Mining Limited (one-third) and Eldor Resources Limited (a subsidiary of Eldorado Nuclear Limited) (one-sixth), signed a surface lease agreement with the Saskatchewan government in August 1981 to develop an open pit operation for the recovery of 73,610 tonnes U from near-surface deposits grading an average 2.0 percent U. Production is scheduled to begin in late 1983, and attainment of the annual design capacity of 4,600 tonnes U would rank Key Lake as the world's largest uranium production centre.

From 1976 until early 1980, Eldorado was marketing agent of Key Lake product for SMDC, and sales were split in the ratio 75 percent SMDC to 25 percent Eldorado. This agreement was terminated in early 1980, except that Eldorado has until now continued to market SMDC product in Japan. The Marubeni and Mitsubishi general trading companies of Japan formed in May 1983 a new firm called Marubishi, which will act as commercial agent for the sale in Japan of all uranium available to Eldorado and SMDC. The Canadian and Saskatchewan Crown corporation partners will share equally in such sales, but Eldorado will be the lead negotiator and will be responsible for administering the contracts. Apart from the previous bids to Japanese utilities, one of which was successful, each of the three Key Lake joint venturers markets its own share of output in competition with the others. When this head-to-head rivalry began in the late 1970s SMDC had no pre-existing contracts and no experienced marketing division, and initially stood at a competitive disadvantage. However, SMDC has now secured purchaser commitments for 80 percent of its product share for 1983-86, and 66 percent of its share for 1983-90.

Protectionism in the United States

From a historical maximum of 16,800 tonnes U in 1980, U.S. production fell to 14,800 tonnes U in 1981 and to 10,330 tonnes U in 1982. Production is not

expected to exceed 7,500 tonnes U in 1983. This severe decline, the steepest over any period in the history of the industry, is a reaction to large inventories and slippages in yellowcake demand growth.[19] There are few signs of a production rebound, and virtually all new investment in domestic uranium exploration and development has been halted. The Department of Energy cut its estimates of domestic reserves in all cost categories from 796,000 tonnes U on 1 January 1981 to 688,000 tonnes U on 1 January 1982.[20] This re-evaluation was prompted in part by depletion through mining of the higher-grade ore, but mostly it is due to rising production costs, which have not been offset by the development of reserves. WOCA uranium resources reasonably assured at forward costs below US$52 per kg U (US$20 per lb U_3O_8) include an estimated 12,700 tonnes of U.S. uranium, barely 2 percent of the WOCA total for this category.[21]

Production facilities have been extensively curtailed since 1980, and in the period from June 1981 to March 1983 ten conventional mills were shut down, including those of Anaconda Minerals, Conoco-Pioneer Nuclear, Energy Fuels Nuclear, United Nuclear and Western Nuclear. These ten installations comprised over 40 percent of 1981 conventional U.S. mill capacity.[22]

The approximately two dozen primary producers still in the field can supply considerably more concentrate than is required to meet their own sales commitments. However, many or most of them have found it more economical to fill delivery commitments by buying or leasing excess utility inventories than by mining and milling their own ore. If these producers continue to substitute cheap spot market material for expensive production to meet their delivery obligations, U.S. output in 1990 could sink to 7,000 tonnes U or less.[23]

Drawdowns of U.S. commercial inventories have begun, and rising shipments will be needed to meet the previously contracted fuel requirements of nuclear generating plants under construction and entering operation. U.S. annual reactor demand, which exceeded production for the first time in 1982, is expected to reach 14,000 tonnes U in 1985 (of which about 10 percent was uncommitted in mid-1982) and could swell to over 17,000 tonnes U in 1990 (45 percent uncommitted).[24] In a worst-case scenario posited by advocates of legislative relief for the imperiled U.S. uranium industry, all unfilled requirements would be met by imports and the use of non-U.S. uranium would increase monotonically from 14 percent in 1982 to 56 percent in 1990.[25]

The protectionists have mounted a vigorous and historically rooted political action campaign to re-interrupt the import of foreign uranium. An embargo on foreign uranium for domestic end use was enacted in 1964 to shield U.S. producers during the 1960s shift to an increasingly civilian market from the exclusive procurement of weapons uranium by the U.S. Atomic Energy Commission.[26] AEC

military purchasing had begun in 1948 and had remained intense for about a decade. The 1960s transition was marked by limited commercial uranium demand, ample Canadian and other foreign supply, low uranium prices, and forecasts of high future requirements for fissile fuels. The 1964 restrictions were considered temporary, and have been relaxed gradually beginning in 1977 to their scheduled expiration at the close of 1983. The AEC (now DOE) was directed to

> 'monitor the extent of importation of foreign uranium for domestic uranium use and its effect on the viability of the domestic uranium producing industry and on the President's objective of achieving a national capability for energy self-sufficiency ... If the extent of domestic use of foreign uranium should impair or threaten to impair the common defense and security, the Commission will institute such measures as are deemed necessary'.[27]

In each of the five years from 1977 to 1981, the aggregate amount of foreign-source uranium enriched for domestic use has been less than one-half of the allowable percentage. In 1980, the domestic use of non-U.S. uranium was 10 percent versus the 30 percent allowable; in 1981, 10.1 percent versus 40 percent; and in the 1977-81 semi-decade, 7.9 percent versus the allowable weighted average of 22 percent. Only 5,100 tonnes U was shipped by foreign suppliers to U.S. users in 1979-81.[28]

The trend is sharply upwards, however, and as of 1 July 1982 uranium import commitments (contracts and firm options) for delivery after 1 January 1982 totalled 41,500 tonnes U. About 85 percent of the 37,200 tonnes U contracted for by U.S. buyers in the 18 months ending 1 July 1982 will be imports.[29]

Until 1983 the USA formally limited imports by restricting enrichment of foreign-source uranium. The Amendment to the Fiscal Year 1983 Nuclear Regulatory Commission budget authorization bill HR 2330 introduced in March 1982 by Senator Pete Domenici (Republican of New Mexico, the largest uranium producing state) stipulated directly that at most 20 percent of the future fuel needs of any given U.S. reactor facility could be supplied by non-U.S. uranium. The Reagan administration opposed this amendment, and a Senate-House Conference Committee raised Domenici's per-reactor ceiling to 37.5 percent of total U.S. demand in September. This semifinal wording passed the Senate on 1 October 1982, but even as moderated the partial embargo was too stiff for the free-traders in the House, which rejected it on 2 December.

Clauses limiting uranium imports were then dropped from the subsequent bill, which finally cleared both Houses of Congress on 17 December. As signed into law, HR 2330 instructs DOE to monitor and for the years 1983 to 1992 report

annually to Congress and the President on the viability of the domestic uranium mining and milling industry. In the language of HR 2330, viability means primarily that:

i executed contracts or options to purchase natural and enriched uranium from non-U.S. suppliers will be less than 37.5 percent of actual or projected domestic uranium requirements for any two-consecutive-year period;
ii domestic economic uranium reserves and uranium production capacity can supply all projected national nuclear power needs for ten years into the future.

If DOE finds that these and other criteria of viability are not being met, or that uranium imports impair national security, the Department of Commerce will investigate and can recommend 'trade adjustments' to protect domestic uranium production.

Renewed actions to shape protective or neo-isolationist legislative vehicles are expected in Congress. According to the Nuclear Assurance Corporation,

> U.S. producers' investment in exploration and development, responding to mid-1980s price increases, will be largely dependent upon the strength of the final uranium import resolution. Only an assured future demand, whether it be 30 percent, 40 percent, or 50 percent, could stimulate further U.S. capital expenditures in the shadow of the expansion capabilities of Jabiluka, Ranger, Key Lake, and other large non-U.S. deposits'.30

If initiatives in the spirit of Senator Domenici eventually raise a new import barrier, domestic industry will need to increase production by commissioning a number of higher-cost uranium mines, and price rises of 25 percent or more in the USA might ensue.31 A slowdown in mine development and production could then occur in Canada and overseas. Meanwhile, utilities in Europe and Asia would have almost exclusive access to the more cost-efficient production, possibly allowing them to pay less for their supplies. Nuexco warns that 'the threat of an embargo may have the same effect on prices as the enactment of one might have done'.32

Stability and Change in Canada

The facilities of Denison Mines Limited in the Elliot Lake area, Canada's historically prime uranium production district, have been in continuous production for the past 25 years. Ore blocks are now mined at depths of up to one kilo-

metre, at an average ore grade of 0.07 percent U. Major expansions to these mines and plants begun in 1978 are being completed to provide fuel for Ontario Hydro, the provincially-owned utility which is advancing interest-free loans to cover substantially all costs of the expansion program. Denison began supplying concentrates to Ontario Hydro in 1980, and was initially scheduled to provide 48,500 tonnes U by the year 2011. Tonnages delivered annually will vary, and will jump in 1994, after the termination of Denison's contract to ship 15,400 tonnes U to the Tokyo Electric Power Company during the decade from 1984 through 1993. Denison's production at Elliot Lake increased from 1,830 tonnes U in 1981 to 2,360 tonnes U in 1982.

In 1981 and 1982 the pair of underground mine-mill facilities of Rio Algom Limited at Elliot Lake produced 2,660 tonnes U and 2,550 tonnes U respectively, at an average grade of 0.07 percent U. Rio Algom in 1978 began rebuilding a third and previously closed down Elliot Lake facility, the Stanleigh mine and mill, which will enter production in July 1983 at an annual rate of 654 tonnes U. Rio Algom contracted in 1978 to deliver all concentrates produced at Stanleigh to Ontario Hydro from 1983 until reserves are exhausted in about the year 2020 (an estimated 27,700 tonnes U). The complete rehabilitation of the Stanleigh complex is also made possible by interest-free loans from Ontario Hydro. Ontario Hydro's extensive loans to Denison and Rio Algom are repayable over the respective delivery periods. The balances owing to Ontario Hydro on 31 December 1982 were C$267.4 million from Denison and C$259.5 million from Rio Algom. These long-term supply arrangements were structured to insulate Ontario Hydro and the two producers against market uncertainties, and are considered to afford Denison and Rio Algom formal assurances of profit and stability seldom if ever gained by industrial enterprises.

Responding in early 1980 to the slowdown in its electric power load growth, Ontario Hydro decided to stretch out construction of new generating stations, and in 1981 negotiated the following reductions in scheduled deliveries:

i about 9 percent from Denison through 2012;
ii 15 percent from Rio Algom from 1983 through 2004.

Yearly supplies from Stanleigh will increase in 2005 and Hydro will still purchase the full Stanleigh output. These adjustments were slated to correct Ontario Hydro's oversupply of uranium in the late 1990s, although they increased its 1985-93 deficit.

In July 1982, Madawaska Mines Limited ceased production at its low-grade mine near Bancroft in eastern Ontario. Agip Nucleare, the Italian government-owned nuclear fuel cycle agency, held a contract to purchase the entire output of the

mine, at annually negotiated prices. However, owing to drastic reductions in the Italian nuclear energy program and its resulting large uranium inventories, Agip Nucleare in early 1982 took the initiative in seeking to terminate its obligations to Madawaska, and the two parties agreed in March to cancel the contract on 30 June 1982. Madawaska was unsuccessful in its bid to supply Ontario Hydro with 2,020 tonnes U in the short term at a price of about C$105 per kg U.

Ontario Hydro shifted its attention and commitment to Key Lake, and decided to cover its 1985-93 shortfall by accepting proposals in June 1982 to purchase 3,120 tonnes U from Uranerz Exploration and Mining and 2,080 tonnes U from Eldorado at prices around or below C$78 per kg U.

Beginning in 1959, Eldorado conducted operations deep underground (deeper than 1.5 kilometres in 1981-82) at the Beaverlodge mine near Uranium City, Saskatchewan. Eldorado permanently terminated mining and milling at Beaverlodge in June 1982 in response to depressed uranium prices, falling ore grades, and increasing production costs. Ore grades had dropped about 40 percent in five years, down to the 1981 level of 0.15 percent U.

Production at Rabbit Lake decreased sharply from 1,967 tonnes U in 1980 to 1,207 tonnes U in 1981 and 1,190 tonnes U in 1982. The Rabbit Lake pit is nearing depletion and is expected to close in late 1983 or early 1984, although ore stockpiles will provide feed to the mill until 1985.

On 1 October 1982, Eldorado acquired all of the shares of Gulf Minerals Canada Limited and Uranerz Canada Limited, in exchange for 4,700 tonnes of uranium held in inventory. (Eldorado received a 5,000-tonne U stockpile from the federal government, through Uranium Canada Limited, in 1981.) As a result, Eldorado is now the sole owner of the Rabbit Lake mine and mill and other uranium properties in the area, including the Collins Bay deposits. These orebodies are located along the major Collins Bay thrust fault, 10 to 12 kilometres north of the Rabbit Lake mine. The Saskatchewan government in December 1982 granted environmental approval for the development of the Collins Bay 'B' deposit, and a surface lease agreement was signed in March 1983. Development of this deposit is expected to maintain production at the Rabbit Lake mill after 1985, at a nominal annual capacity of 1,930 tonnes U.

Mine Closures and Company Shifts to New Deposits

The main shifts in uranium production capacity are depicted in the following three tables. Current and future scheduled uranium mine closures in Canada and

Australia are listed in table 4. Table 5 summarizes recent efforts by several established producers to gain footholds in major new-generation uranium deposits, while oil company efforts to leave uranium projects in Saskatchewan and Australia are shown in table 6.

TABLE 4. URANIUM MINE CLOSURES IN CANADA AND AUSTRALIA

Mine and type of recovery	Owner	Location	Starting Date	Closure Date	Ore Grade (percent U)
Beaverlodge (underground)	Eldorado	Uranium City, Saskatchewan	1959	1982	0.15
Madawaska (underground)	Federal Resources 51% Consolidated Faraday 49%	Bancroft, Ontario	1975	1982	0.07
Mary Kathleen (open pit)	CRA 51%[a] AAEC 42%[b]	Central Queensland	1976	1982	0.10
Rabbit Lake (open pit)	Eldorado (formerly Gulf Minerals and Uranerz Canada)	Northeastern Saskatchewan	1975	1983 or 1984	0.19
Agnew Lake (underground in-situ leaching)	Kerr Addison	East of Elliot Lake, Ontario	1977	1983	0.04

Source: Company reports.

[a] CRA Limited was formerly named Conzinc Riotinto of Australia Limited
[b] AAEC = Australian Atomic Energy Commission

In early 1978, Denison reached an agreement with the Inexco Oil Company of Houston to purchase Inexco's one-third share of the Key Lake uranium property for US$159.5 million. Under Inexco's joint venture agreement with SMDC and Uranerz Exploration and Mining, however, the two partners held the right to match the offer. SMDC alone exercised this option, and purchased Inexco's holding in November 1978. SMDC then sold one-half of this new asset to Eldorado.

TABLE 5. COMPANY EFFORTS TO ENTER OR ACQUIRE NEW-GENERATION URANIUM PROJECTS

Company	Project	Date	Outcome
Denison	Key Lake	1977-78	Denison's acquisition of Inexco shares was blocked by SMDC, exercising a right of first refusal
Mary Kathleen	Ranger	late 1970s	MKU's bid for the AAEC shares in Ranger was rejected by Canberra
Denison	Koongarra	1980	Deposit purchased from Noranda, production target 1986
Eldorado	Collins Bay 'B'	1982	Property purchased from Gulf Minerals Canada, production target 1985

Source: Company reports.

TABLE 6. OIL COMPANY EFFORTS TO LEAVE ONGOING URANIUM PROJECTS, CANADA AND AUSTRALIA, 1982

Project, Location	Company	Partner Firms	Action Taken by Company
Midwest, Saskatchewan	Esso Minerals	Numac, Bow Valley Mink Mining, Midwest Mining	decommissioned the project site
Dawn Lake, Saskatchewan	Asamera	SMDC, SERU Nucléaire, Reserve Oil	transferred field operation to SMDC
Waterbury Lake, Saskatchewan	Asamera	SERU Nucléaire, SMDC, Reserve Oil	sold its 12 percent share to Idemitsu Kosan of Japan
Rabbit Lake, Saskatchewan	Gulf Minerals	Uranerz Canada	sold all interests to Eldorado (Uranerz Canada also sold its interests to Eldorado)
Yeelirrie, Australia	Esso Exploration	Western Mining, Urangesellschaft	withdrew from partnership

Source: Company reports.

When its bid to enter the Key Lake venture was thus blocked,[33] Denison turned to Australia, and in October 1980 acquired the Koongarra uranium deposit from Noranda Mines. Denison estimates the reserves at Koongarra, located 25 kilometres southwest of Ranger, at 11,500 tonnes U, lying close to the surface, and projects the delivery of 1,150 tonnes U annually to the market beginning in 1986. However, production at Koongarra cannot begin until satisfactory agreements are reached in compliance with Aboriginal land rights, and with foreign investment policy objectives calling for 50 percent or more Australian equity in uranium mines. Denison was considered well advanced towards these objectives in early 1983.

In the late 1970s, Mary Kathleen Uranium Limited (owned 51 percent by CRA Limited of Melbourne and 41.6 percent by the Australian Atomic Energy Commission) attempted unsuccessfully to acquire the AAEC's share of the Ranger uranium project, and did not further pursue its interest in Ranger. The Mary Kathleen mine in Queensland, which produced some 4,100 tonnes U since it was recommissioned in 1976, was closed in late 1982 owing to its limited ore reserves and the soft market.

The Role of Government

Owing to the strategic and sensitive nature of nuclear commerce, governments have from the outset been key actors at each stage of the nuclear fuel cycle. At the front end, the mining and milling of uranium is the most highly monitored and controlled of all mineral production activities.

The U.S. government shaped the international fuel supply industry through its former monopoly of uranium enrichment services, which facilitated the implementation of its now-expiring embargo on uranium imports. Each of the main producer nations outside the U.S. has mechanisms in place to regulate directly the terms and conditions of uranium development, including pricing and delivery schedules. As the overseers of contracts and exports, government agencies in Canada and Australia can influence, if not control, the rate at which new production comes on stream, and in some cases the scope of individual projects.

All Australian mining companies with approval to develop uranium production centres must obtain a Ministerial Determination outlining terms and conditions which must be included in their sales contracts. These standards include an indexed floor price formula, designed originally by Canberra to sever the link to the spot market and enhance the bankability of Australia's extensive new development projects. Trade in uranium lends itself to the conclusion of long-term contracted supplies at prices reflecting long-term market equilibrium,

rather than reliance on the uncertain and volatile spot market'. A floor under uranium prices 'would, if generally adopted, offer the best prospect for market stability and the orderly development of the international industry'.[34]

At their economic summit meeting in Tokyo in 1979, the western industrialized nations and Japan committed themselves to the replacement of oil by coal and nuclear energy. The next three annual Summit Conferences, which meanwhile acquired new political and strategic dimensions, further stressed the necessity of concrete long-term measures to widen the coal and nuclear energy options. But despite the appreciable advantages of the extensive uranium reserves now being developed in Canada and Australia, and the potential in the two countries for commerically exploitable new deposits (which according to some could establish the competitiveness of uranium over coal), the assistance which Ottawa, Canberra and the provinces might lend to the nuclear industry is limited. Government intervention in the free enterprise economies cannot create new demand or an upsurge in the utilization of established resources for civil nuclear energy. The merchant marketplace, or the investor's perception of the marketplace, remains the chief determinant of the timing of new uranium mining projects. In today's period of uncertainty and insecurity arising from the declining rate of nuclear power installation, the less competitive uranium mines are being closed, and some older producers are leaving the industry. Faltering markets have signalled a cautious approach to the deployment of risk capital for the development of all but the best-endowed properties.

The attention of mining companies focuses increasingly on competing projects in Saskatchewan and Australia's Northern Territory, and on Yeelirrie in Western Australia. If the profound technological, economic, and political complexities of the Olympic Dam copper-uranium-gold project can be mastered, it could have a weighty impact on the uranium situation of the 1990s.

Uranium producers in Canada and Australia argue that the reimposition of U.S. import restrictions will lead to a two-tiered world uranium price structure, which would further damage the exploration and development prospects required to supplement reserves and assure deliveries into the next century.[35] The governments of Canada and Australia have sought political agreements within the General Agreement on Tariffs and Trade to resist protectionist measures that limit trade, and have urged the United States not to adopt the Domenici Amendment or kindred successor legislation.[36]

While the prudence of establishing import quotas undergoes heated debate, more U.S. uranium production capacity is being idled and the producer-exporters of Canada and Australia are taking the market lead. But the Canadian government's uranium policies were put in place in the mid-1970s and do not necessarily reflect the exigencies of today's uncertain and fluctuating world market.

Knowledge of the market and its interaction would be improved by a clearer understanding of Ottawa's system for uranium export contract approval. Such knowledge would facilitate planning and analysis in industry and government, and would increase the confidence of consumers of Canadian uranium. Each export contract negotiated by a Canadian uranium producer is examined for consistency with government policies by the Uranium Exports Review Panel (UERP), an advisory body with members from Energy, Mines and Resources Canada (whose Assistant Deputy Minister for the Conservation and Non-Petroleum Sector chairs the Panel), the Atomic Energy Control Board, the Department of External Affairs, and the Department of Industry, Trade and Commerce. Decisions of the panel are reached by consensus. Without serious loss of regulatory flexibility or commercial confidentiality, measures might be devised to better illuminate the various steps and decision-making parameters along the administrative route traversed by a producer-consumer agreement under consideration by the Review Panel.

Energy, Mines and Resources Canada in March 1977 informed Canadian uranium producers that provision should be made in all future sales contracts for an escalating floor price 'which will protect investment in production facilities'.[37] In view of the considerable attention now spotlighted on the contract price issue, study and discussion could be encouraged on the experiences of government and producers with minimum pricing provisions embedded in the export review process since 1977.

In their application to the difficulties presented by the uncertain market regime, the measures proposed here for an increased flow of information and analysis could only indirectly influence Canada's approach to points at issue in the uranium trade. But once underway, they could form a more solid basis than exists at present for the pursuit of policy options to promote orderly and rational long-term solutions to problems of world energy supply and uranium resource development.

PART I NOTES

1. Nuclear Energy Prospects to 2000, a joint report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency (Paris: OECD, 1982) p. 8. Industry leaders stress moreover that 'for producers, cash flows have been reduced due to weak markets in all minerals, including oil and gas, as well as uranium. This, combined with high interest rates and high inflation, has led to cuts in production and exploration and to delays in development'. Jim Bonny, Vice President, Saskatchewan Mining Development Corporation, and Murray Fulton, 'The Uranium Equation in 1982', paper presented to the Uranium Institute Symposium, London, 1-3 September 1982.

2. George White, Jr., Vice President, Nuexco, 'U.S. Utilities Said Entering U Market', The Northern Miner, 15 July 1982, p A27. (Nuexco is a California-based uranium brokerage and market monitoring company.) The Nuexco inventory figures exclude the substantial tonnages owned by the U.S. Department of Energy (about one-half of all U.S. inventories), and contained in other national, non-utility stockpiles.

   A utility user of uranium holds title to varying quantities of the following materials: enriched uranium not yet inserted in a reactor, natural uranium hexafluoride, and uranium concentrates. The aggregate of these substances is termed the uranium inventory of the user. Status of the U.S. Uranium Industry August 1982 (Washington, D.C.: Department of Energy, August 1982) p. 31. Hereafter cited as Status 1982.

   Reactor demand for uranium is defined by DOE as the scheduled quantity of uranium in tonnes per year which must be delivered to enrichment plants to meet scheduled reactor fuel requirements. Uncommitted demand is the fraction of uranium demand that is not covered by contracts with suppliers.

3. WOCA inventories peak later in the decade than U.S. stockpiles owing to the longer duration of non-U.S. uranium contract commitments, and to the effects of overseas bulk enrichment purchases. The inventory figures quoted in this paragraph assume no significant relief from existing enrichment plant contract schedules.

4. J.R. Wolcott, President, Nuexco, 'Uranium: An Uncertain Market', paper presented to the Uranium Institute Symposium, London, 1-3 September 1982.

5. Uranium is traded directly between buyers and sellers, and not in a metals exchange. A spot contract is one which calls for the delivery of a fixed quantity of uranium concetrate within a specified short period, usually less than one year, but in some cases up to two years. Spot contracts generally entail only one delivery of material. The annual spot market volume is around 10 percent of the overall uranium market. Prior to the wave of inventory trading in uranium which rose in 1980, spot sales were either pre-planned by producers, or the result of an unanticipated mining surplus. C. Colhoun, Nukem, 'The Spot Market for Uranium', paper presented to the World Nuclear Fuel Market, Nice, 19 October 1982. (Nukem GmbH is a West German firm which offers a wide range of uranium fuel cycle services.)

6. 'Detailed price information relating to deliveries under long-term contracts has been difficult to obtain in the past, whereas spot-price indicators have been published for years by Nuexco and Nukem. One of the consequences of the lack of price information in the long-term market is a tendency by the industry to focus on the spot-price indicators and to refer to them as barometers of the total market'. R.S. Livingston, Chairman, Australian Uranium Export Office, 'Can Market Stability be Improved?: Government and Export Contract Approvals', paper presented to the Uranium Institute Symposium, London, 1-3 September 1982.

7. George White, Jr., July 1982.

8. Gunther Lurf and Nicholas M. Nikazmerad, Nukem, 'Utility Procurement Policies in the United States', paper presented to the Uranium Institute Symposium, London, 1-3 September 1982. The delivery period on intermediate term contracts is generally between two and five years.

9. R.T. Whillans, Energy, Mines and Resources Canada, 'Uranium', Canadian Mining Journal, February 1983, pp. 123, 128. Shipments of primary uranium were estimated at 7,507 tonnes U in 1981 and 8,189 tonnes U in 1982, valued respectively at C$794 million and C$815 million (R.T. Whillans, pp. 123-124). The weighted average price for 1982 under all export contracts made by Canadian producers for deliveries in 1982 was C$113 per kg U (US$35.50 per lb U_3O_8) (R.T. Whillans, p. 128). This weighted average price nearly coincided with the US$35.55 average contract price for 1982 of reported deliveries by U.S. producers to U.S. consumers. See Survey of United States Uranium Marketing Activity, Report No. DOE/NE-0013/1 (Washington, D.C.: Department of Energy, July 1982) p. 7. Hereafter cited as Survey 1982.

10. Uranium in Canada: 1980 Assessment of Supply and Requirements, Report No. EP 81-3 (Ottawa: Energy, Mines and Resources Canada, September 1981) pp. 11-12.

11. Survey 1982, pp. 2, 14. Less than 8 percent of the uranium committed for delivery in 1982-90 by U.S. producers will be taken by foreign buyers.

12. The low average grade for WOCA uranium reserves is due to the preponderance of large low-grade reserves in Namibia, the province of Ontario, South Africa, the United States, and other areas.

13. Statistical Data of the Uranium Industry, Report No. GJO-100 (82) (Grand Junction, Colorado: Department of Energy, 1982) p. 54. Similar secular declines have occurred in the production of copper, a traditional bellwether of the minerals industry, as well as gold and other market-mature metals. The average grade of economically minable copper ore has decreased more or less steadily for the last 80 years, from about 5 percent in 1900 to around 0.7 percent in 1978-79. See Peter A. Aucoin, Nuclear Assurance Corporation, 'Uranium: Just Another Metal?', paper presented to the Nuclear Assurance Corporation Uranium Colloquium, Grand Junction, Colorado, 6-7 October 1982. (Nuclear Assurance Corporation is a data services and consulting company in the nuclear fuel cycle industry with particular experience in uranium market analyses.)

14. Chamber of Mines of South Africa, 1980 Annual Report, p. 79.

15. L.S. Beck, Executive Director, Geology and Mines, Saskatchewan Energy and Mines, 'Saskatchewan Seen Top 'U' Producer Here', The Northern Miner, 15 July 1982, p. B4. Despite the softening of the uranium market after mid-1979, industry and government in Saskatchewan are hopeful that committed exploration and development drilling expenditures will sustain the province's high discovery rate. Uranium exploration expenditures and drilling are now concentrated on properties in the vicinity of the Rabbit, Key, and Cluff Lake projects.

16. M.J. Denner and P.L. Reeves, Uranium Reserves and Potential of Northern Saskatchewan, Report No. 81-5 (Regina: Saskatchewan Energy and Mines, 1981) p. 20.

17. Hugh Douglas, 'Reserves/Grade Relationships by Type of Uranium Deposit: Key to Strategies for Securing Future Uranium Supplies', paper presented to the Uranium Institute Symposium, London, 2-4 September 1980.

18. D.W. Weaver, Nuclear Assurance Corporation, 'The Cost of Uranium', paper presented to the Nuclear Assurance Corporation Uranium Colloquium, Grand Junction, Colorado, October 1981. The NAC average full cost of production capacity figures contain capital costs, operating costs, and return on all capital and operating costs. Although the uranium industry does not publish cost data, Saskatchewan producers regard the NAC figures as reasonably accurate.

19. Paul de Vergie et al., Production Capability of the U.S. Uranium Industry (Grand Junction, Colorado: Department of Energy, October 1982) p. 2. In 1982, domestic production dropped for the first year below reactor demand in the USA.

20. Status 1982, p. 6. Reserves recoverable as of 1 January 1982 are broken down into cost brackets in the following table, from Status 1982, p. 6. Forward production costs are defined as the capital and operating costs that would be incurred in the future production of concentrate, and exclude previous expenditures on acquisition, exploration, development and construction, as well as taxes, profits and the cost of money.

Changes in U.S. uranium reserves during 1981

Forward cost per kg U ($lb\ U_3O_8$)	US$78 ($30)	US$130 ($50)	US$260 ($100)
Recoverable reserves tonnes U	158,000	458,000	688,000
Percent reduction over 1 January 1981 estimate	56	25	14

21. J.R. Wolcott, September 1982. Very little if any U.S. uranium production can be sustained at under US$52 per kg U (US$20 per $lb\ U_3O_8$). De Vergie, October 1982, p. 1.

22. De Vergie, October 1982, p. 2. The mills of at least two other firms have subsequently also been closed. Conventional mills exclude solution mining and byproduct operations. These and other nonconventional sources milled 21 percent of the total U.S. uranium output in 1981.

23. Nukem Market Report, May 1982, p. 4.

24. Status 1982, pp. 39-40.

25. Status 1982, p. 37.

26. The Atomic Energy Commission's gaseous diffusion facilities then possessed a monopoly of WOCA commercial enrichment capacity, and the embargo was implemented by prohibiting the enrichment in these installations of foreign uranium for domestic end use.

27. 39 Federal Register 38016, 25 October 1974.

28. The statistics in this paragraph are from Status 1982, pp. 34-35. Fifty one percent of the foreign feed delivered by domestic enrichment customers in 1981 was of Canadian origin, 22 percent Australian and 20 percent South African. Survey 1982, p. 16.

29. The statistics in this paragraph are from R. Gene Clark, 'Survey of United States Uranium Marketing Activity', paper presented to the Nuclear Assurance Corporation Uranium Colloquium, Grand Junction, Colorado, 6-7 October 1982.

30. F.J. Hahne III, Nuclear Assurance Corporation, 'Future Uranium Prices', paper presented to the Nuclear Assurance Corporation Uranium Colloquium, Grand Junction, Colorado, 6-7 October 1982.

31. Status 1982, p. 54.

32. Nuexco Monthly Report on the Nuclear Fuel Market, December 1982, p. 15. Emphases by Nuexco.

33. Denison sought other opportunities to mine high grade Saskatchewan ore by exploring for unconformity-type deposits in the Athabasca Basin and Wollaston Lake fold belt with Mitsui, SMDC and Westmin, but none of these joint ventures is currently active.

34. R.S. Livingston, London, 1-3 September 1982.

35. George R. Albino, Chairman, Rio Algom Limited, Petroleum News interview with Stephen Salaff, December 1982, p. 15; Tony Grey, Chairman, Pancontinental Mining Limited, Petroleum News interview with Stephen Salaff, August 1983.

36. A.R. Hollbach, Energy, Mines and Resources Canada, 'Federal Government Uranium and Nuclear Industry Policies', paper presented to the Canadian Nuclear Association Symposium on Uranium and Nuclear Industry Issues, Toronto, 3 November 1982. Mr. Hollbach explained the general nature of the Canadian representations to Washington: 'The Canadian government resisted the introduction of this legislation from the time it was first proposed by Senator Domenici in 1980. We have presented several diplomatic notes and

have had bilateral discussions to remind the U.S. government that, in our view, such legislation is in contravention of U.S. GATT obligations ... The Canadian government, in cooperation with the Canadian uranium industry, will continue to urge the United States government not to proceed with the legislation. The problems of the U.S. uranium industry are not caused by imports but by slowdowns in the U.S. nuclear power program'.

37. R.M. Williams, Energy, Mines and Resources Canada, 'Uranium', Canadian Minerals Yearbook 1977, No. 53, p. 7.

PART II URANIUM IN SASKATCHEWAN: HISTORY, PRODUCTION, AND DEVELOPMENT PROSPECTS

Introduction

Major North American, West Europe and Japanese explorer-developers are engaged in a concerted effort to exploit the high grade uranium deposits of northern Saskatchewan. The cycle of uranium exploration, development and production in Saskatchewan displays the relatively rapid fluctuations of supply and demand which characterize the international uranium mining industry: beginnings stimulated by atomic bomb manufacture in the 1940s; boom in response to the even greater fissionable-material needs of thermonuclear weapons construction in the early 1950s; a dozen years of severe recession in reaction to the decline in military procurement; and then the second and third waves of intense exploration expenditures in 1968-71 and 1975-81 leading to the location of important new deposits.

Table 1 summarizes historical data on the principal uranium deposits in northern Saskatchewan. The first two of the new Saskatchewan uranium mining projects were at Rabbit Lake and Cluff Lake, where orebodies were found in 1968 and 1969 respectively. After a lull in the early 1970s, another discovery cycle was heralded by the location of large reserves in 1975 and 1976 at Key Lake, where mining will begin in mid-1983. When industry and government began considering the systematic pre-development of the deposits discovered in 1978-81, demand weakened internationally. In mid-1979, spot market prices for uranium concentrates began a precipitate three-year decline. The spot market upturn since late 1982 has thus far been only tentative. The commercial success of Saskatchewan's uranium producers in the 1980s depends on revitalization of the nuclear power industry and a rally of the uranium fuel supply market.

History

Stimulated by the market created by the military demand of the United States and Great Britain, prospectors delineated a number of uranium orebodies in northwestern Saskatchewan during 1946-52. Between 1948 and 1960, two large underground mines, those of Eldorado Nuclear Limited and Gunnar Mining Limited, and fourteen smaller orebodies were brought into production in the Beaverlodge Mining District near Uranium City, just north of Lake Athabasca.[1] These mines were supported by three facilities for milling uranium ore into uranium concentrates (U_3O_8). Annual combined production from Saskatchewan uranium mines in the Beaverlodge camp peaked at 3,835 tonnes U in 1958.

TABLE 1. NORTHERN SASKATCHEWAN URANIUM DEPOSITS

Year of discovery, defined as first drill intersection	Name of deposit (years of production) Underground (ug) or open pit (op)	Ownership
1946	Beaverlodge (1953-82) ug	Eldorado
1952	Gunnar (1955-63) op, later ug	Gunnar Mining
1968	Rabbit Lake (1975-83 or 84) op	Eldor Mines (formerly Gulf Minerals)
1969	Fond du Lac	Eldorado, Amok
1969	Cluff 'D' (1980-83) op	Amok, SMDC
1970	Cluff 'N'	Amok, SMDC
1971	Collins Bay 'A'	Eldor Mines (formerly Gulf Minerals)
1972	Cluff 'Claude' (from 1984) op	Amok, SMDC
1972	Raven	Eldor Mines (formerly Gulf Minerals)
1973	Cluff 'OP' (from 1984) ug	Amok, SMDC
1974	Horseshoe	Eldor Mines (formerly Gulf Minerals)
1975	Gaertner (Key Lake)	SMDC, Uranerz Exploration, Eldor Resources
1976	Deilmann (Key Lake)	SMDC, Uranerz Exploration, Eldor Resources
1977	Maurice Bay	SMDC, Uranerz Exploration, Eldor Resources
1977	West Bear	Eldor Mines (formerly Gulf Minerals) SMDC, Noranda
1977	Collins Bay 'B' (from 1985) op	Eldor Mines (formerly Gulf Minerals)
1978	Midwest	Esso Resources, Numac, Bow Valley, Mink Mining, Midwest Mining
1978	Dawn Lake No. 11 and No. 14	SMDC, Asamera, SERU Nucléaire Reserve Oil
1979	McClean North	CanadianOxy, Inco
1980	Eagle Point	Eldor Mines (formerly Gulf Minerals) SMDC, Noranda
1980	McClean South	CanadianOxy, Inco
1980	Dawn Lake No. 11A and No. 11B	SMDC, Asamera, SERU Nucléaire, Reserve Oil
1981	Waterbury Lake	SERU Nucléaire, SMDC, Idemitsu Kosan, Reserve Oil
1982	JEB	CanadianOxy, Inco

Sources: N. Saracoglu et al., 'The McClean Uranium Deposits, Northern Saskatchewan - Discovery', CIM Bulletin, April 1983, p. 65; T.I.I. Sibbald et al., Saskatchewan Uranium Field Trip Guide, (Calgary: Geological Association of Canada, 1981)

Closely integrated with the United States in the industrial and military-political fields, Canada in this period sold 90 percent or more of its total uranium output under firm contracts with U.S. Atomic Energy Commission (AEC). The AEC, however, adopted a uranium self-sufficiency policy in November 1959, when to the consternation of the Canadian producers it announced the non-renewal of these contracts.[2] Compounding the difficulty for the Canadian uranium industry, the U.S. government enacted legislation in August 1964 which prevented foreign suppliers from exporting uranium to the USA for use in its domestic reactors.[3] Furthermore, the USA possessed a monopoly on provision of uranium enrichment services which was not broken until the mid-1970s, and used its hegemony to encourage foreign enrichment service customers to buy U.S. uranium at prices above those on the open market. Not until 1977 did the USA again allow a percentage of domestic end-use uranium imports.

By 1964, most if not all of Canada's smaller uranium mining firms had closed their operations, and Saskatchewan production declined to a minimum of 460 tonnes U in 1971. Eldorado Nuclear Limited, a federal commercial Crown corporation, was the only producing company in Saskatchewan, where it survived with the aid of a 1965-70 federal subsidy and stockpiling program and by reducing in 1968-71 the production capacity of its deep underground Beaverlodge mine at Uranium City. From 1958 to 1966, Eldorado 'stretched' its existing contracts with the AEC,[4] and purchased outstanding contracts from other mines in the area which were forced to close. During the 1978-80 'boom' period, Eldorado committed large capital expenditures to accelerate the development of new assets and to refurbish existing facilities at the Beaverlodge operation. Nevertheless, after three decades of mining activity in the Uranium City area, during which it produced a total of approximately 16,800 tonnes U, Eldorado permanently closed its Beaverlodge facilities in June 1982. Ore grades had declined about 40 percent in five years to the 1981 level of 0.13 percent U, and Eldorado cited increased production costs, falling ore grades and soft uranium markets to explain the shutdown.

Eldorado also operates Canada's only uranium refinery at Port Hope, Ontario, where mill concentrates are converted into a range of products including uranium metal, uranium hexafluoride (which is shipped to the USA and Europe for enrichment and fabrication into fuel for light water nuclear power reactors), and uranium dioxide (the fuel for Canada's line of Candu heavy water reactors).

The rescue stockpiling and subsidy measures undertaken during the 1960s on political and strategic grounds by Canada and other producer nations provided only limited assistance to the uranium industry. The Canadian government contends that the U.S. uranium import embargo of 1964 compelled it to join in self-defense with state agencies and mining companies in France, South Africa,

Great Britain and Australia to establish a producers' association, or uranium cartel. Critics of this arrangement claim that over a number of years it fixed uranium prices in violation of anti-trust laws in the USA and Canada, and they attribute the uranium price climb of 1974 to 1976 at least in part to this grouping. However, the Canadian government pointed out that the abrogation by the Westinghouse Corporation in September 1975 of long-term uranium supply contracts with approximately twenty electric power utilities which purchased its light water reactors was also a factor in the more-than-quadruple uranium price increase.

Eldorado and Gulf Minerals Canada Limited, historically the largest uranium producers in Saskatchewan, were listed as cartel members. The French government's Atomic Energy Commission (CEA), the Compagnie Française des Minerais d' Uranium (renamed in 1980 the Compagnie Française de Mokta (CFM), a member of the Imetal Group), and Pechiney Ugine Kuhlmann were also identified by U.S. legislative and judicial agencies as cartel participants. The nuclear fuel cycle firm Cogema (a full CEA subsidiary), CFM, and Pechiney Ugine Kuhlmann are the shareholders of Amok Limited of Saskatoon, developer of the Cluff Lake project.

New Production Centres

Even during the world uranium recession of the 1960s, it was expected that prices would eventually rise, as other energy supplies grew scarcer and more expensive, and as nuclear power began significant penetration of markets for electricity generation stations. With the commercialization of fission energy, uranium exploration accelerated in northern Saskatchewan, financed in substantial measure by foreign-national enterprises. In late 1968, Gulf Minerals Canada Limited located a major deposit at Rabbit Lake, on the east rim of the Athabasca Sandstone Basin. This 80,000-square-kilometre Basin resembles an ellipse 425 kilometres long and 225 kilometres wide situated south of Lake Athabasca and west of Wollaston Lake.

> The Rabbit Lake discovery, together with improving forecasts for uranium demand, precipitated a land staking rush unequalled in Canadian mineral exploration history. By early 1969, almost all of northern Saskatchewan had been claimed by mineral permits. Also, a first for Canadian mineral exploration was the nature of the companies engaged in this rush; most were oil rather than mining companies. Land was acquired in 'one shot' in permits covering thousands of square kilometres following the oil industry style.[5]

Uranerz Canada Ltd, owned by C. Deilmann A.G. (10 percent) and Rheinische-Braunkohlenwerke A.G. (a member of the Rheinisch-Westfaelisches Elektrizitaetswerk (RWE) Group of energy producers) (90 percent), teamed with the Gulf Oil Corporation in 1969 to construct the Rabbit Lake facilities and

exploit the Rabbit Lake orebody. Uranerzbergbau GmgH, formed in Bonn, West Germany in 1968 and owned in equal shares by the same two German firms, joined with a number of U.S. and Canadian companies to explore for uranium in Canada. The West German government, striving to utilize its ample financial potential to gain long-term access to overseas uranium production, has supported Uranerz as well as Urangesellschaft GmbH of Frankfurt with subsidies for prospecting and exploration, favourable tax writeoffs, and agreements to share the risks arising from obligations to take delivery of uranium concentrates secured through joint venture participation in new production projects. During its first ten years, Uranerz Bonn and its subsidiaries expended an estimated C$160 million in worldwide exploration and development of uranium resources. Of this total, approximately $96 million was invested in Canada. The Rabbit Lake project was developed by Gulf Minerals Canada Limited (45.9 percent) and Gulf Canada Limited (5.1 percent), and Uranerz Canada Limited (49 percent).

Much of the Gulf-Uranerz deposit was situated under Rabbit Lake, which was dammed and drained in 1972 to allow open pit mining. The Rabbit Lake mill came on stream in 1975, and from 1977 to 1980 its annual production was between about 1,800 and 2,000 tonnes U, ranking Rabbit Lake along with the Elliot Lake producers as one of Canada's three largest uranium operations. Production diminished however to 1,207 tonnes U in 1980 and 1,190 tonnes U in 1982. The average grade of ore processed at the Rabbit Lake mill has fallen from about 0.34 percent U in 1975 to 0.19 percent U in 1983. Rabbit Lake uranium has fueled the power reactors of the RWE Group and other West German utilities, and of consumers in Canada, the USA, Switzerland, Finland, Spain, and Japan.

In October 1982, Eldorado Nuclear Limited acquired all of the shares of Gulf Minerals Canada Limited and Uranerz Canada Limited in exchange for uranium concentrates form Eldorado's inventory. As a result, the Rabbit Lake mine-mill complex is now solely owned and operated by Eldor Mines Limited. The formerly Gulf-owned Collins Bay deposits, the nearby Eagle Point deposit, and all remaining Gulf Minerals assets in Saskatchewan are now held by Eldor Mines Limited. Eldor Mines expects to complete the mining of the Rabbit Lake deposit in late 1983 or early 1984, and to replace it with the Collins Bay 'B' deposit. This deposit was discovered in 1977, partially below water in Collins Bay, an inlet on Wollaston Lake 9 kilometres northeast of the Rabbit Lake mill. With an ore grade averaging about 0.38 percent U, the reserves of Collins Bay 'B' are estimated at 12,040 tonnes U. Saskatchewan environmental approval for the development of these reserves was granted in December 1982, and a surface lease, was signed in March 1983. The Rabbit Lake mill is slated to begin processing ore from the Collins Bay 'B' deposit in mid-1985, at an annual rate of 2,120 tonnes U. Development of this project will involve 'an innovative scheme which utilizes the old Rabbit Lake pit as a waste disposal site'.6

Amok Limited began exploration for uranium in Saskatchewan in 1964. Prompted by the Compagnie Française de Mokta's discovery of economic uranium deposits in Precambrian sandstone in Gabon and Niger, West Africa, Amok investigated radiometric anomalies in the multi-ring Carswell circular structure in the west central part of the Athabasca Basin. Employing innovative glacial geology interpretation methods for tracing radioactive boulder trains back to their source area, originated in Scandinavia and then developed by Canadian and French geologists, Amok prospectors in 1969 discovered the Cluff Lake 'D' orebody. This near-surface deposit was relatively small (4,000 tonnes U) but very high grade (7 percent uranium). Several other more conventional grade (0.2 to 0.6 percent uranium) orebodies were found nearby.

The May 1978 Final Report of the provincially appointed Cluff Lake Board of Inquiry approved Amok's Phase 1 proposal, and recommended that uranium mining should proceed in the province under certain controlled conditions. The Report considered both site-specific and provincial issues, and questions of world energy needs, nuclear reactor safety, the disposal of high level radioactive wastes, and nuclear weapons proliferation. It concluded that nuclear power, despite a number of acknowledged risks, is an indispensable option in an energy-short world. A supportive assessment process and active promotion of the uranium industry by both New Democratic and Conservative governments of Saskatchewan differ from the restrictive responses of several other provinces. These restraints have included a seven-year moratorium on uranium exploration and mining (British Columbia, 1980), a moratorium on the issuing and renewing of uranium exploration licenses (Nova Scotia, 1981), and the withholding of a development license for the Kitts-Michelin uranium project in eastern Labrador on environmental grounds (Newfoundland, 1980). Under conditions of what it termed the 'historically chaotic' uranium market, the Cluff Lake Final Report (pp. 160-161) even took a benign view of the export quota and minimum price arrangements established by Canada and other producers in 1972.

Cluff Mining is 80 percent owned by Amok and 20 percent by the Saskatchewan Mining Development Corporation, a Crown corporation formed by the Government of Saskatchewan in 1974 to participate in the development of the hard-rock mineral sector of the province's resources industry. In Phase 1 of the Cluff Lake project, a mill was built with an annual capacity of 1,500 tonnes U and with special provision for processing the very high grade 'D' orebody. The mining and surface stockpiling of this deposit was completed in October 1981, and will supply the mill until mid-1984. Cluff Mining has identified five nearby ore zones for Phase 2 of the project. These are the Claude, N, N40, OP and Dominique-Peter deposits, which contain total reserves of approximately 12,700 tonnes U. The proposal calls for open pit mining of the Claude and N orebodies, and underground mining of the OP, N40 and Dominique-Peter ore zones from a sin-

gle decline utilizing cut-and-fill mining techniques. Because of the lesser grade of uranium in these five deposits, extensive renovations are underway to enable the mill to process larger volumes of ore. Cluff Mining's schedule calls for construction of Phase 2 process facilities beginning in summer 1983, and for production from late 1984 until 1995 at an annual rate of between 850 and 1,250 tonnes U. Cluff Mining has signed long term contracts to ship Phase 1 and Phase 2 concentrates to French and West German utilities.

Observers have noted that 'the Rabbit and Cluff Lake discoveries switched uranium exploration interest away from the Beaverlodge District to the sedimentary basin of the Precambrian (Paleohelikian) Athabasca Formation and particularly to the contact or unconformity at the base of the formation'.[7] After an intensive exploration program beginning in 1969, Uranerz Exploration and Mining Limited utilized boulder tracing techniques to discover in 1975 the Gaertner orebody and in 1976 the Deilmann orebody extending under Key Lake and several smaller nearby lakes within the southeastern boundary of the Athabasca Basin. These deposits occur at the unconformity between the overlying Athabasca sandstone and the underlying steeply dipping basement rocks. Most of the reserves are associated with altered graphitic basement rocks, with lesser amounts in the overlying sandstone.

In February 1979, the Key Lake Mining Corporation (KLMC) was formed by SMDC, Uranerz Exploration and Mining Limited, and Eldor Resources Limited (wholly owned by Eldorado Nuclear Limited) with holdings of one half, one third and one sixth respectively. KLMC in 1979 performed a surface drainage operation, partially constructed a well-dewatering facility, and sank 23 dewatering wells. Public hearings of the Key Lake Board of Inquiry into the probable environmental, health, safety, social and economic effects of the Key Lake Project began in February 1980. The Board's January 1981 Final Report endorsed the KLMC mining proposal, and in August 1981 the owners signed a 21-year surface lease with the Department of Northern Saskatchewan. The Key Lake reserves equal 73,608 tonnes U, at an average grade of 2.0 percent U, and KLMC plans to compiete by August 1983 construction of an open pit mine-mill facility designed to produce 4,600 tonnes U annually. Achievement of this target would rank Key Lake as the world's largest producing uranium mine.

Development Prospects

The 1968-71 exploration impetus was blunted when the market refused to expand in the early 1970s. However, Saskatchewan's second exploration boom around the rim of the Athabasca Basin was driven by the surge in uranium prices which began in 1974, and by the discovery of the Key Lake deposits in 1975-76. Saskatchewan

uranium exploration expenditures of $70.5 million in 1979 (54.4 percent of the total for Canada) rose to $77.2 million in 1980 (60.3 percent of the national total). Oil companies and their corporate affiliates accounted for over one-quarter of the 1979 uranium exploration expenditures, and for more than one-third of the 1980 total.[8] Table 2 shows that uranium exploration expenditures began a marked decline in 1981.

TABLE 2. URANIUM EXPLORATION INDICATORS, CANADA AND SASKATCHEWAN

	Uranium Exploration Expenditures (millions of dollars)						
	1976	1977	1978	1979	1980	1981	1982
Canada	44	71.7	90.0	129.5	128.0	102.1	
Saskatchewan	13[a]	35.3	43.6	70.5	77.2	60.8	45[b]

	Uranium Exploration Drilling and Surface Development Drilling (thousands of metres)					
	1976	1977	1978	1979	1980	1981
Canada	155	304.1	333.9	483.3	503.3	358.8
Saskatchewan	78[a]	192.4	233.4	326.6	368.6	300.7

Sources: Energy, Mines and Resources Canada, and Saskatchewan Energy and Mines.

[a] Approximate figures only.
[b] Includes a non-uranium fraction, possibly around 20 percent, of expenditures incurred in provincial exploration for base and precious metals.

A shift in emphasis occurred in exploration programs in 1981-82, due largely to the 1979 uranium market collapse. Overall exploration philosophy has turned away from grassroots reconnaissance-scale projects, and in order to consolidate their land holdings companies are now concentrating their efforts on the delineation drilling of potential ore zones. Exploration dollars are being allocated to fewer projects, and activity is focused only on high-potential properties in the vicinity of the known deposits.[9] The most important development prospects are listed in table 3.

TABLE 3. URANIUM DEVELOPMENT PROSPECTS IN NORTHERN SASKATCHEWAN

Project and Mining Methods	Partners	Comments
Midwest: open pit (underground option was examined)	Esso Resources (50%) Numac Oil and Gas (25%) Bow Valley Industries (12.5%) Mink Mining and Midwest Mining (12.5%)	Partners shelved the project in 1982, citing poor market outlook. Exxon is withdrawing from the uranium industry.
McClean Lake: underground	CanadianOxy (50%) Inco (50%)	Inco's underground method for mining high grade ore being considered for testing starting in 1984; may become a model for the other new underground projects in the area.
Dawn Lake: underground	SMDC (54.586%) Asamera (26.889%) SERU Nucléaire (11.025%) Reserve Oil and Minerals (7.5%)	Now operated by SMDC. Asamera ended its active participation in 1982. SERU Nucléaire is expected to play a growing role. Bore-hole mining technologies are being studied, as well as underground mining methods.
Waterbury Lake: underground	SERU Nucléaire (33.625%) SMDC (50.75%) Idemitsu Kosan (11.875%) Reserve Oil and Minerals (3.75%)	Idemitsu Kosan of Japan purchased Asamera's equity in October 1982. Further drilling is being carried out in 1983 to determine the extent of the mineralization.

Source: Company reports.

Midwest

After Key Lake became established as a 'model' for unconformity-type uranium deposits, deep drilling to the base of the Athabasca sandstone at the Midwest project led to the discovery in early 1978 of a high grade deposit 200 metres under a shallow arm of South McMahon Lake, within the Athabasca Basin near its eastern margin, and 25 kilometres northwest of the Rabbit Lake mine.10

The Midwest property is owned by Esso Resources Canada Limited (a wholly owned subsidiary of Imperial Oil Limited) (50 percent), Numac Oil and Gas Limited of

Edmonton (25 percent), Bow Valley Industries Limited of Calgary (12.5 percent), and two U.S. investment corporations (12.5 percent). The proposed development of the property was officially put on hold in November 1981, but an Environmental Impact Statement was submitted to the provincial and federal governments early in 1982 which called for an open pit mine and mill producing 1,500 tonnes U annually, beginning in 1988, from ore grading 1.9 percent U. Resources were given as 21,600 tonnes U, of which 15,200 tonnes U were recoverable by open pit mining. Since the project was put on hold, attention has switched to the possible future development of the property by underground mining.

During the uranium market downturn which began in 1979, Imperial Oil's parent firm, the Exxon Corporation, and other oil companies shifted their investment programs and policies away from uranium development and mining. The Midwest property is one of the smallest uranium acreages in northern Saskatchewan, and offers little scope for further exploration after delineation of the major deposit. Thus, the Midwest joint venture decommissioned the project site and removed the exploration camp in 1982. The current demise of Midwest illustrates the political and economic difficulties which have beset exploration for uranium in Saskatchewan since the peak years 1978-80, and which could discourage investors in the neighbouring McClean, Dawn and Waterbury Lake projects.

McClean Lake

In 1979 and 1980, Canadian Occidental Petroleum Limited (Canadian Oxy) and its equal joint venture partner Inco Limited discovered the McClean North and McClean South uranium deposits 10 kilometres northwest of the Rabbit Lake mine. At depths varying from 152 to 175 metres, this pair of deposits contains reserves estimated at 5,390 tonnes U, grading an average 1.5 percent U. In 1982, the joint venture discovered a third high grade mineralized zone, called the 'JEB', 10 kilometers north of the McClean deposits.

The primary radiation protection concern that arises in the underground mining of higher grade ores is the concentration of radon daughters (the short-lived decay products of radon gas).[11] Engineers are now considering methods designed to reduce or minimize levels of exposure to radon daughter products in underground mining. Cluff Mining proposes to control radiation by utilizing the conventional cut-and-fill method for the underground mining of the OP, N40 and Dominique-Peter orebodies, where grades range from 0.3 to 0.6 percent U.[12] Other methods involve:

i removal of ore from its deposit area by high pressure remote hydraulic techniques;

ii the dissolution of ore in situ and raising of the solutions to the surface for uranium recovery.

A conceptual study for underground test mining of the high grade McClean deposits was completed by Inco in December 1982, and is now the subject of discussions with the Atomic Energy Control Board in Ottawa and with regulatory agencies in Saskatchewan. The new process combines a number of conventional underground mining techniques which have been utilized by Inco and CanadianOxy in recovery of other metallic minerals. While details of the McClean Lake mining process have not yet been published, the joint venture is requesting approval for a two-year pilot program for the proposed mining method, beginning in 1984, and is seeking a third partner to help fund the test mining. The McClean Lake underground mining method might if successful become a model for the mining of nearby orebodies such as Dawn Lake and Waterbury Lake.

Dawn Lake

Company-estimated reserves at the 1,550 square kilometre Dawn Lake uranium property, whose perimeter surrounds the Midwest project, total 15,400 tonnes U, at an average grade of 0.93 percent U. The depth of each of the four separate mineralized zones is from 100 to 150 metres, and their total strike length is 2,150 metres. Asamera Incorporated, the Calgary oil and gas firm which operated the Dawn Lake project from 1975 to 1982, had planned a feasibility test in the summer of 1982 for an unconventional bore-hole hydraulic method to mine these uranium-bearing pods. Before making this test, however, Asamera took steps to end its active presence in Saskatchewan, and resigned as operator of the Dawn Lake project. The candidate mining systems being researched by new project manager SMDC include borehole technologies of both conventional and unconventional types, semi-remote mining using automated equipment, and in-situ leaching.

As of mid-July 1983, Dawn Lake shareholders were SMDC (54.586 percent), Société d'Etudies et de Recherches d'Uranium (SERU Nucléaire Canada Limited, a full subsidiary of Cogema) (11.025 percent), Asamera (26.889 percent) and Reserve Oil and Minerals Corporation of New Mexico (7.5 percent). However, SMDC was negotiating the sale of 4.5 percent of its interest in the project to the Korea Electric Power Corporation (KEPCO), which recently also signed long-term uranium purchase contracts with SMDC. Asamera was in the process of selling 15 percent of its share to SERU Nucléaire and the remainder to Japanese concerns including the Power Reactor and Nuclear Fuel Development Corporation.

Waterbury Lake

The Waterbury Lake deposit was discovered in 1981 by SERU Nucléaire, which is now conducting delineation drilling to measure reserves deeply buried under 410 to 440 metres of sandstone cover. Located west of the McClean Lake property, and west and southwest of the Dawn Lake property, the Waterbury Lake project is owned by SMDC (50.75 percent), project operator SERU Nucléaire (33.625 percent), Idemitsu Kosan Co. Ltd. (11.875 percent) and Reserve Oil and Minerals (3.75 percent). Idemitsu Kosan, Japan's largest independent petroleum company, took its first step into the Canadian uranium field by purchasing Asamera's share in the project in October 1982.

Other Areas of Activity

Significant funds are being expended in exploring for uranium in the Rabbit Lake-Dawn Lake area. Eldorado is concentrating much of its exploration activity around the mineralized zones on the Collins Bay trend, and Uranerz is pursuing projects near the Key Lake mill. Cluff Lake is the other main area of ongoing uranium exploration activity in northern Saskatchewan.

Construction of a regional mill to serve possible future mining operations on the eastern margin of the Athabasca Basin has been discussed for some years in industry and government. In addition, companies with commercially promising deposits in the Rabbit Lake area that are too small to warrant the dedication of a project mill are keenly interested in the custom milling potential of Eldorado's Rabbit Lake mill, where surplus capacity could become available in the early 1990s, when the processing of the Collins Bay 'B' orebody is scheduled to approach completion. A consortium of developers might be assembled to negotiate milling arrangements with Eldorado which, if technical mill parameters permit, may favour tolling for such a regional producers group in order to supplement and eventually replace throughput from Collins Bay 'B'.

Conclusion: A New Challenge

Saskatchewan's uranium output is expected to more than double when the Key Lake project comes on stream in late 1983. Saskatchewan will then supplant Ontario as Canada's largest producer of uranium concentrates, and will lead Canada past the United States into first place among uranium producers in the world outside centrally planned economies area.

The vulnerability of Saskatchewan's uranium economy was nevertheless illustrated in 1982, when Gulf and Exxon among the majors, and Asamera among the independents, decided to withdraw from the province. This reversal of commitment, fourteen years after oil companies began their rush for new uranium claims, is symptomatic of the exploration downturns following the peak years 1948-52, 1967-71 and 1979-80, and may cloud the development prospects of the projects in which these petroleum firms were pivotal.

With strategic mandates from their governments, the French and West German companies which developed the Cluff Lake and Key Lake projects persevered through all phases of the Saskatchewan uranium cycle. Furthermore, the quickened pace of activity of the French government's more recent arrival, SERU Nucléaire, which began uranium exploration in northern Saskatchewan in 1975, is encouraging to the exploration fraternity. SMDC and Eldorado, the two Crown corporations which hold Canada's equity in Saskatchewan uranium production, utilized state financing to enter new production projects (Cluff, Key, Rabbit/Collins 'B') and advanced exploration ventures (Dawn, Waterbury, Collins 'A'and 'B', Eagle Point). In Eldorado's case the federal uranium stockpile was used as well. Can these two government firms and other Canadian enterprises successfully meet the challenge of new explorer-developer roles to maintain the expansion tempo of the Saskatchewan uranium industry?

PART II NOTES

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